

NASA EEEE Parts Management / NEPP Overview

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To be presented by S. Douglas at the 2024 Quality Leadership Forum, March 14, 2024

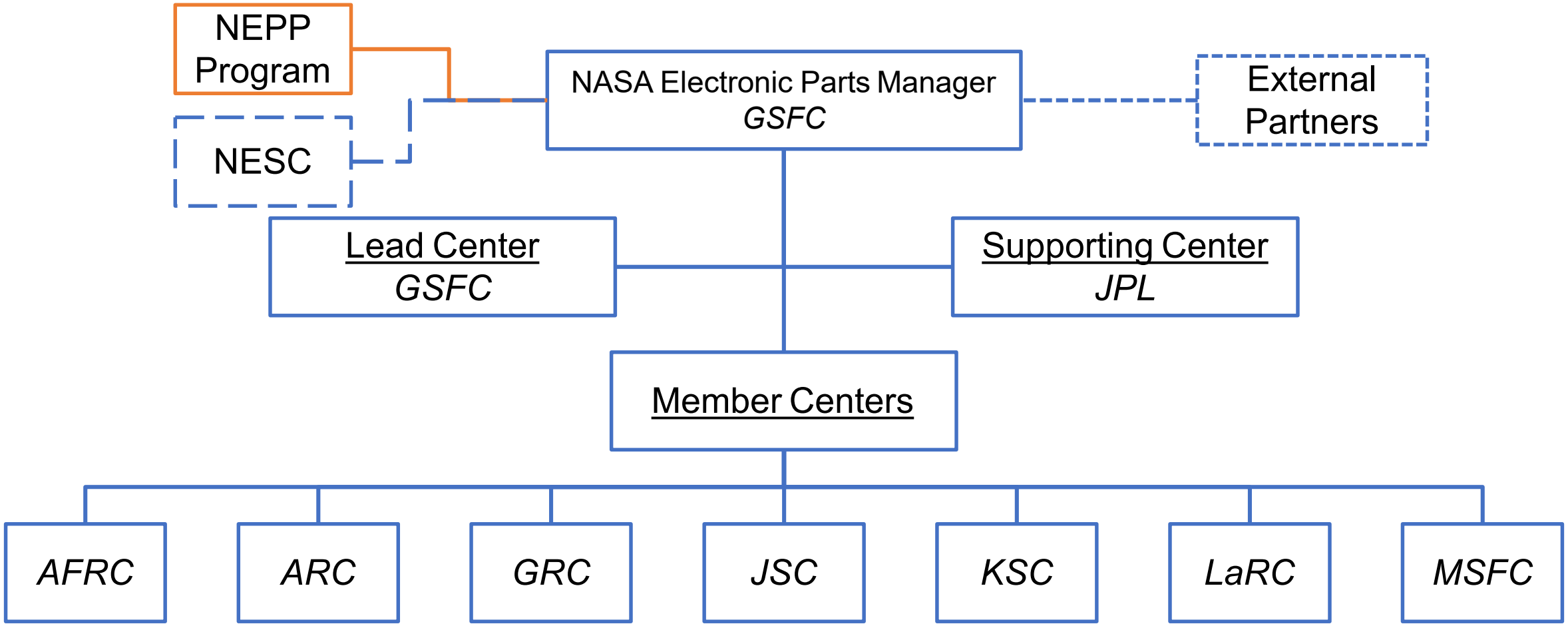
Acronyms

3DHI	Three-Dimensional Heterogeneous Integration
AFRC	Armstrong Flight Research Center
AFRL	Air Force Research Laboratory
ARC	Ames Research Center
BGA	Ball Grid Array
AU	Auburn University
BNL	Brookhaven National Laboratory
BoK	Body of Knowledge
DLA	Defense Logistics Agency
DSBGA	Die-Size Ball Grid Array
EEEE	Electrical, Electronic, Electromechanical, Electro-Optical
ETW	Electronics Technology Workshop
DoD	Department of Defense
DPA	Destructive Physical Analysis
DTRA	Defense Threat Reduction Agency
FPGA	Field-Programmable Gate Array
FFRDC	Federally Funded Research and Development Center
GRC	Glenn Research Center
GSFC	Goddard Space Flight Center
GWG	Government Working Group
IGA	Internal Gas Analysis
JEDEC	Joint Electron Device Engineering Council
JFAC	Joint Federated Assurance Center
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
LBNL	Lawrence Berkeley National Laboratory

MBMA	Model Based Mission Assurance
MDA	Missile Defense Agency
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NEPAG	NASA Electronic Parts Assurance Group
NEPP	NASA Electronic Parts & Packaging (Program)
NESC	NASA Engineering & Safety Center
NPR	NASA Procedural Requirement
NRL	Naval Research Laboratory
NSRL	NASA Space Radiation Laboratory
NSWC	Naval Surface Warfare Center
NVM	Non-Volatile Memory
OSMA	Office of Safety and Mission Assurance
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
RHA	Radiation Hardness Assurance
SAE	Society of Automotive Engineers
SCALE	Scalable Asymmetric Lifecycle Engagement
SCRM	Supply Chain Risk Management
SEE	Single Event Effects
SIBWG	Space Industrial Base Working Group
SMA	Safety and Mission Assurance
SRHEC	Strategic Radiation-Hardened Electronics Council
STD	Standard
TAMU	Texas A&M University
UCF	University of Central Florida
UMD	University of Maryland
U.S.	United States (of America)
WBG	Wide Bandgap

NASA EEEE Parts Management

Manage and coordinate EEEE parts and radiation engineering capability and needs for the Agency



EEEE = Electrical, Electronic, Electromechanical, Electro-optical

NEPP Mission Statement

- NASA's leadership
  - Development and maintenance of guidance for **reliable use of EEEE parts**
  - Characterization, lot acceptance, screening, and qualification testing
  - Collaborations
    - Academia
    - Industry
    - International partners
    - Other Government Agencies

- Central (Agency) Organization
  - Programs and Projects (P&Ps) need to do less (in theory) 
  - Increase "characterization" testing that will apply to most P&Ps
  - More leadership in providing guidance, standards & BoKs

NASA Electronic Parts Assurance Group



SUPPORT DEFENSE STANDARDIZATION PROGRAM / DEFENSE LOGISTICS AGENCY (DLA)

- Perform manufacturer audits with DLA
- Review MILSPEC Changes
- Support JEDEC and SAE Working Groups

TELECONFERENCES

NEPAG
- Weekly Domestic
- Monthly International

Government Working Group
- Biweekly

Other specialty areas
- Hybrids
- 2.5 & 3D Packaging
- Small Mission Success
- Learn @ Lunch Webinars (Vendor Presentations, Parts Engineering School)

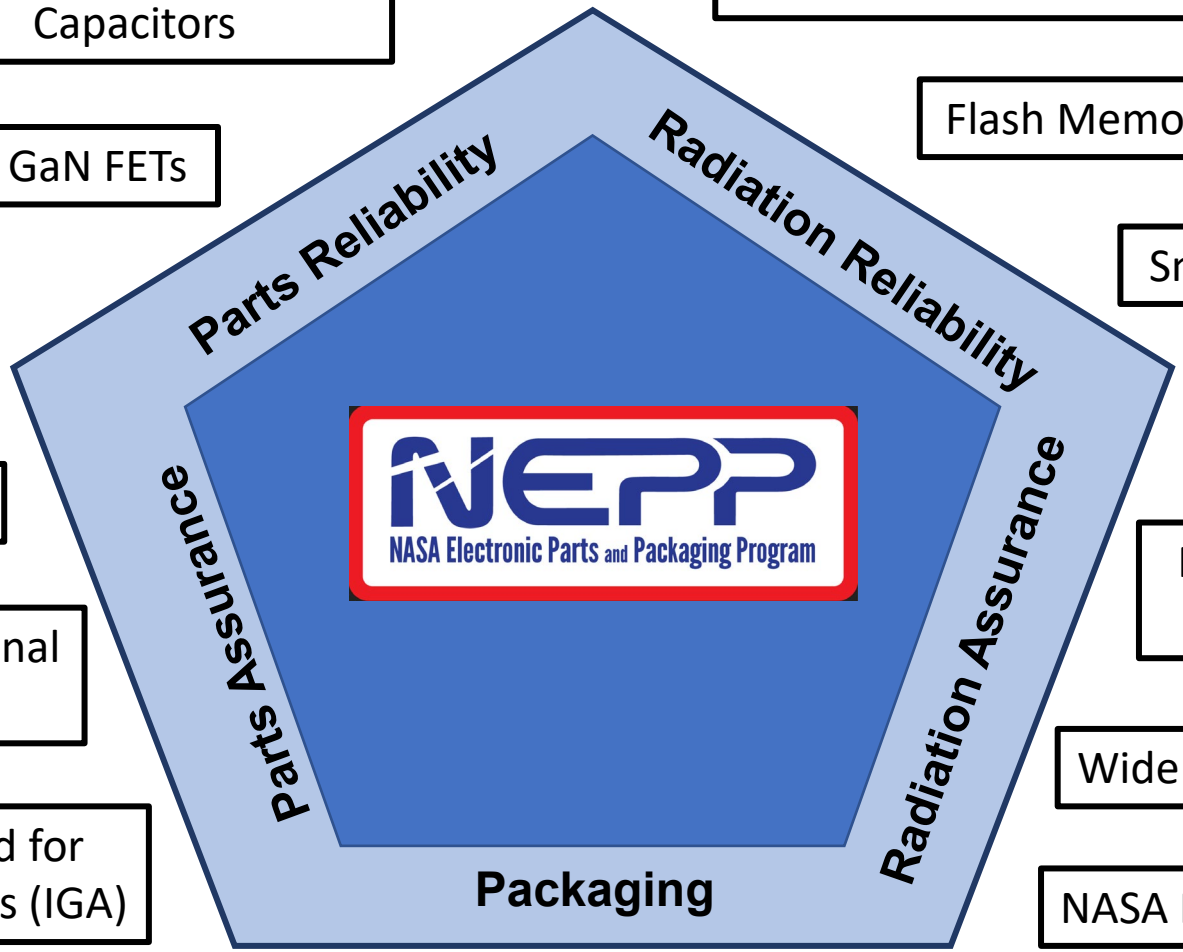
EEEE parts and materials supply chain discussions held in forums

DLA Audits
- VPT Components (MIL-PRF-19500)
- EPC Space (MIL-PRF-19500)
- Micropac (MIL-PRF-19500)
- Hughes Circuits (Printed Circuit Boards)
- Semi Gen (MIL-PRF-19500)
- Semitronics (MIL-PRF-19500)

MIL SPEC Revisions
- “Hybrid microcircuit" definition in MIL-PRF-38534 & 38535
- MIL-STD-1580 DPA

JEDEC / SAE Task Groups
- Photonic ICs
- Bond Strength
- Derating
- IGA
- MIL-PRF-ATM (3DHI Packaging)

Special Circumstance Groups
- Crane DC-DC converter qual failures
- BAE RAD510 Qualification



Evaluation of Al Polymer Capacitors

NEPP Processor Enclave

Evaluation of GaN FETs

Flash Memory RHA

MILSPEC / DLA Support

SmallSat RHA

NASA Standards

Heavy Ion Testing Bootcamp

Domestic & International Teleconferences

NASA Support of NRL Pulsed Laser Comprehensive Handbook

Wide Bandgap / SOA Power Device RHA

Moisture standard for Internal Gas Analysis (IGA)

NASA RHA Technical Standard

PEM Fracture Mechanics

MIL-PRF-ATM Support

HALT/HASS for Class P

Leveraging Interagency Collaborations

Partners

Missile Defense Agency (MDA)

Strategic Radiation-Hardened Electronics Council (SRHEC)

Office of the Under Secretary of Defense for Research & Engineering Trusted and Assured Microelectronics (OUSD(R&E) T&AM) Program

Naval Surface Warfare Center (NSWC) Crane

Defense Logistics Agency (DLA)

U.S. Naval Research Laboratory (NRL)

Air Force Research Laboratory (AFRL)

Aerospace Corporation

Workforce development support
- Texas A&M University (TAMU) Bootcamp
- NASA Parts Engineering School

RHA evaluations for
- Field-Programmable Gate Arrays (FPGAs)
- Wide-Band Gap (WBG) Power Devices
- Non-Volatile Memory (NVM)

RHA testing guidelines for
- Pulsed-Laser SEE
- Photodetectors and Sensors

EEEE parts radiation data sharing

Heavy ion test facility access
- DoD funded beam time

Supply chain risk reduction

NASA Standards & Guidelines Accomplishments

Published

Phase II of the NESC Recommendations on Use of COTS Electrical, Electronic, and Electromechanical (EEE) Parts for NASA Missions
https://ntrs.nasa.gov/citations/20220018183

NASA Guidelines for Ball Grid Array (BGA) and Die-Size BGA (DSBGA) Selection and Application
https://nepp.nasa.gov/docs/tasks/076-Packaging-Assurance/Guidelines-BGA-DSBGA-Ghaffarian-2022July20-CL22-3574.pdf

Guidelines for Screening, Lot Acceptance, and Derating of Polymer Tantalum Capacitors for Space Applications
https://ntrs.nasa.gov/citations/20220019033

Defense Threat Reduction Agency (DTRA) Pulsed-Laser Single-Event Effects (SEE) Testing—A Practical Desk Reference
https://apps.dtic.mil/sti/trecms/pdf/AD1204115.pdf

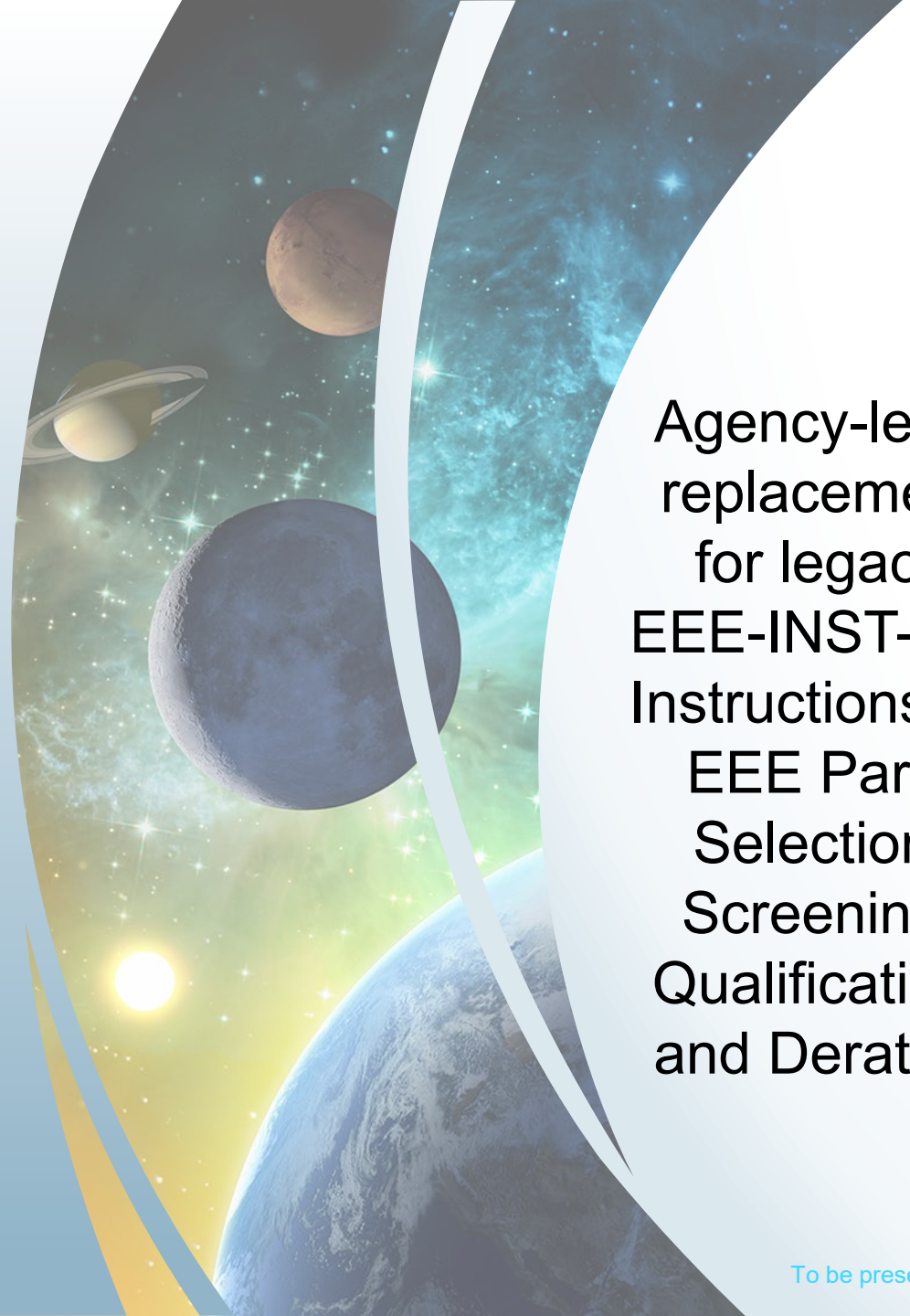
Coming Soon

*NASA Radiation Hardness Assurance (RHA) Standard for Space Flight Hardware**

RHA for Photodetectors and Image Sensors Test Guideline

*NASA-STD-8739.11 EEEE Parts Selection, Testing, and Derating Standard**

** Preliminary draft released at request*



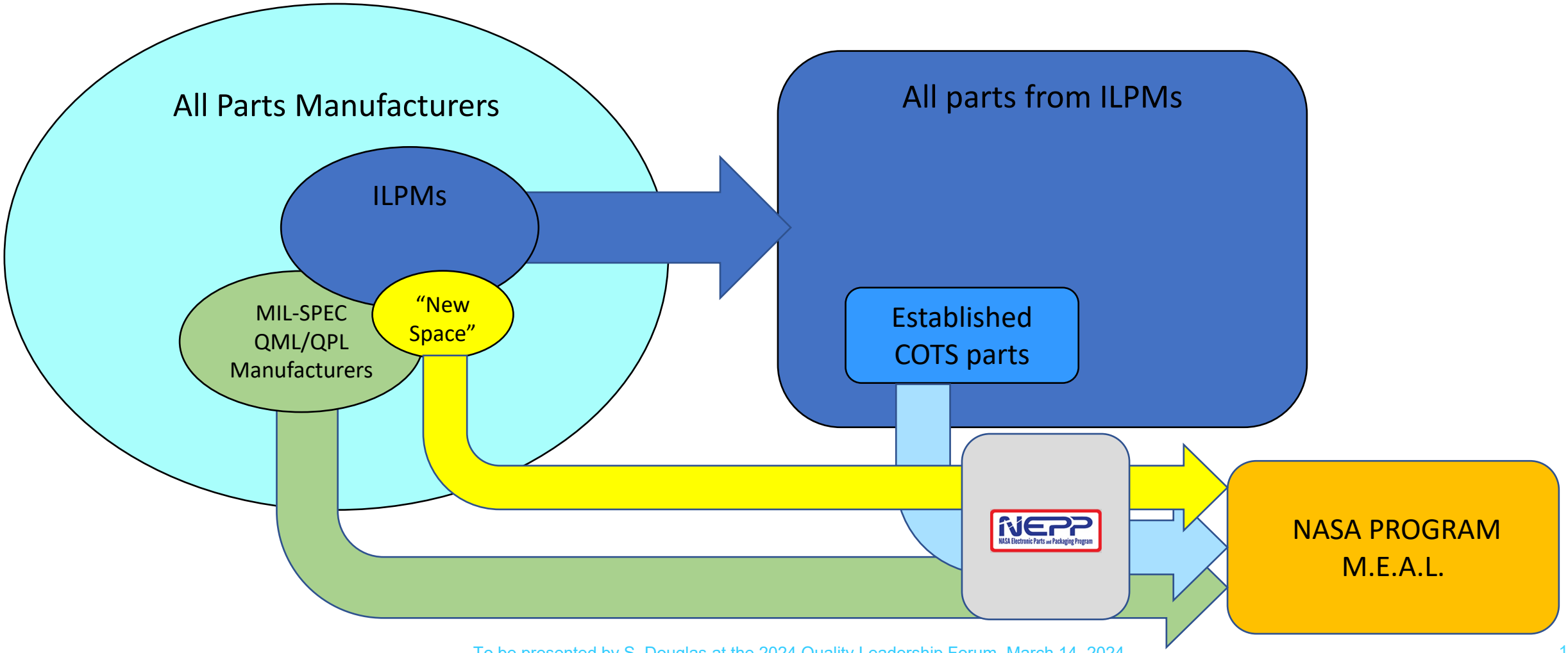
NASA-STD-8739.11 (441 pages)

Agency-level replacement for legacy EEE-INST-002 Instructions for EEE Parts Selection, Screening, Qualification, and Derating

LIST OF SECTIONS

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NASA COTS Implementation Approach: ILPM Pathfinder – Big Picture



What Is An ILPM?

NESC Report defined an **Industry Leading Parts Manufacturer (ILPM)** as:

> A parts manufacturer with high volume automated production facilities and which can provide documented proof of the technology, process, and product qualification, and its implementation of the best practices for “zero defects” for parts quality, reliability and workmanship.

ILPM Criteria

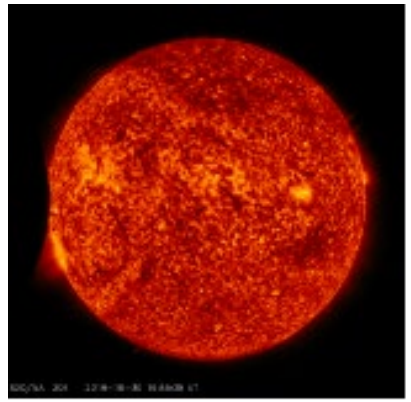
1. Must have at least one Established COTS Part category
2. Willing to share parts quality and reliability data with NASA (DPPM, FIT) and how those statistics are derived
3. Willing to provide NASA documents substantiating parts quality and reliability
4. Willing to work with NASA or prime contractors to maintain a strong customer-manufacturer relationship (preference for on-site visit)

An Established COTS Part is a Part That:

- Is produced using processes that have been stable for **at least one year** so there are enough data to verify the part's reliability.
- Is produced in **high volume**. High volume is defined as a series of parts sharing the same datasheet having a combined sales volume over one million parts during the part's lifetime.
- Is **100% electrically tested per datasheet specifications** at typical operating conditions in production. Additionally, the manufacturer must have completed multi-lot characterization over the entire set of operating conditions cited in the part's datasheet, prior to mass production release.
- Is produced on fully **automated production lines** utilizing statistical process control (SPC), and undergoes in-process testing, including wafer probing for microcircuits and semiconductors, and other means appropriate for other products (e.g., passive parts).
- Has demonstrated **consistent yield** trend appropriate for high volume commercial technologies at that technology node.

Radiation Concerns

- Parts assurance levels in EEE-INST-002 and equivalent documents do not indicate the level of radiation tolerance, and thus the selection of parts level 1, 2, or 3 does not imply or provide any type of radiation hardness or mitigation of radiation effects
- MIL-SPEC parts with and without a radiation hardness designator, signifying TID performance, may still be sensitive to SEE
- Lot-to-lot variation of radiation sensitivity may be larger for non-radiation-hardness-assured (non-RHA) parts than for RHA parts, since space radiation tolerance is typically not designed and optimized for parts without radiation addressed in their datasheets
- RHA mitigations must include system-level techniques and not depend solely on part-level robustness



Credit: NASA/GSFC

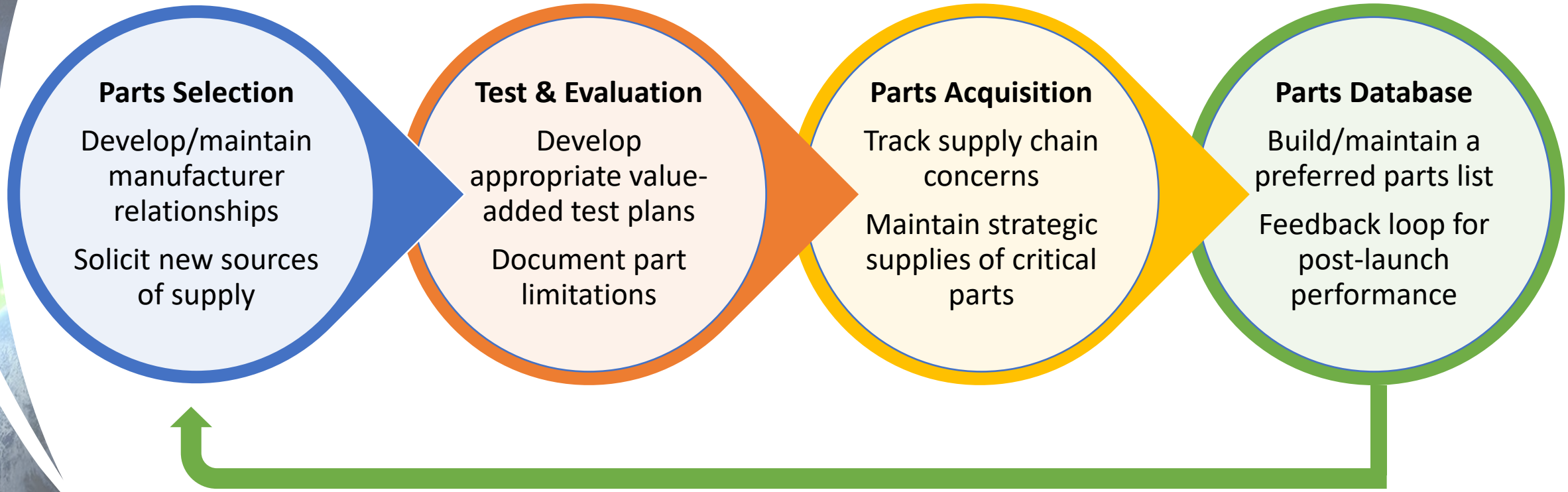
Radiation Hardness Assurance (RHA) Standard for Space Flight Hardware

- RHA methods rely on risk avoidance (part-level RHA), risk management (system-level RHA), or hybrid approach (concurrent engineering)
- Integrates the RHA activities into the program schedule or project lifecycle. Early start of RHA activities and adherence to the stipulated timeline of tasks and deliverables is critical to meet performance requirements in the mission radiation environments and balance budget, schedule, and risk posture constraints.

Table 6. SEE Taxonomy – RHA Scope and Assurance

RHA Category	S1	S2	S3	S4	S5
Risk tolerance posture	Low	Low-Medium	Medium-High	High	Highest
Anticipated scope of SEE testing[6-6]	Piece-part heavy ion characterization test data if not already available. Additional testing as needed for NDSEE characterization, low-LET-threshold parts proton susceptibility, CCA-level for complex system interactions (e.g., SW and HW) validation, etc.	Combination of CCA- and piece-part-level, high-energy proton and heavy ion testing. Additional testing as needed for NDSEE characterization, low-LET-threshold parts proton susceptibility, CCA-level for complex system interactions (e.g., SW and HW) validation, etc.	Combination of CCA- and piece-part-level, high-energy proton and heavy ion testing[6-7]	CCA-level high energy proton testing	None

The Pursuit of a Future NASA EEEE Parts Capability: Parts Evaluation and Assessment Laboratory (PEAL)



Methods for Selecting Parts

Quality/Performance Expectation

CURRENT METHOD

MIL-SPEC PARTS → MIL-SPECs, Test Methods, SMDs, Slash Sheets, DLA, In-line (IL) and End of Line Testing (EOL)

COMMERCIAL PARTS → Data Sheets / Online info → EOL Testing

PEAL

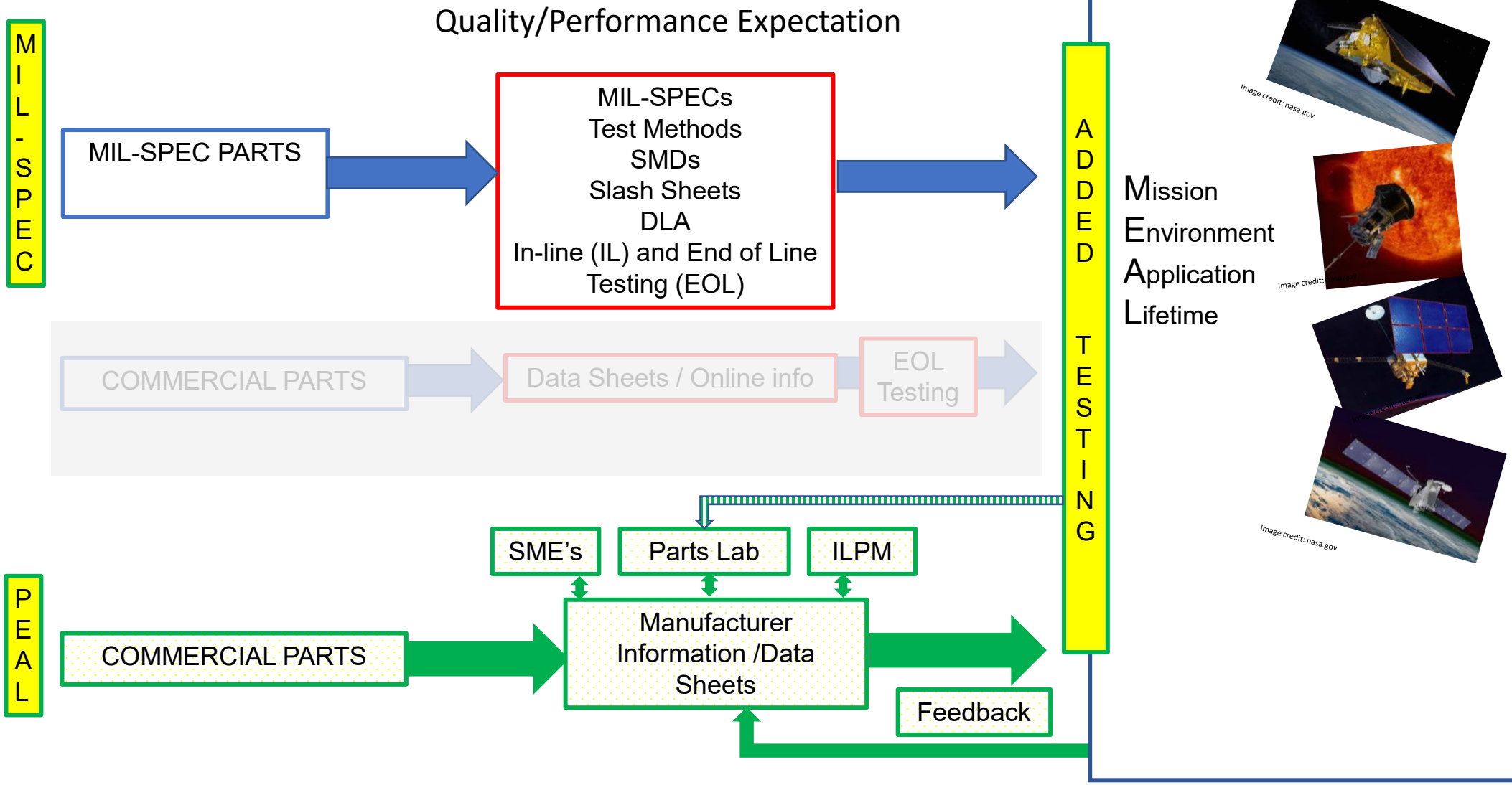
COMMERCIAL PARTS → Manufacturer Information /Data Sheets (SME's, Parts Lab, ILPM)

ADDED TESTING

Mission
Environment
Application
Lifetime



Methods for Selecting Parts





Cost of Not Implementing PEAL

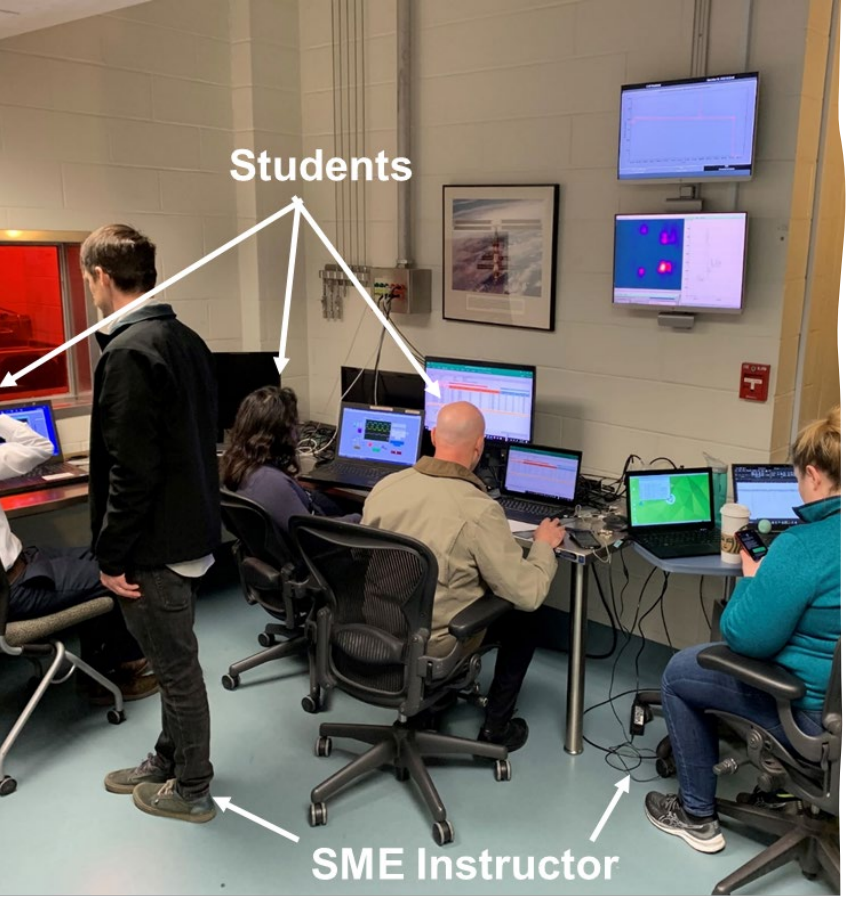
- Major impediments to the use of new technology with the potential for high reliability in space missions
- Tendency to maintain outdated heritage designs that are not only costly and time consuming, but keep us rooted in the past
- Continued reliance on the use of parts that are growingly rapidly in cost and very long lead time, and too often uncertain delivery
- No easy path for taking proven technologies into flagship missions
- Risk of repeating testing efforts for multiple projects across the Agency that can be solved centrally
- Lack of knowledge-base in the NASA community about current EEEE part technology advancements

Workforce Development

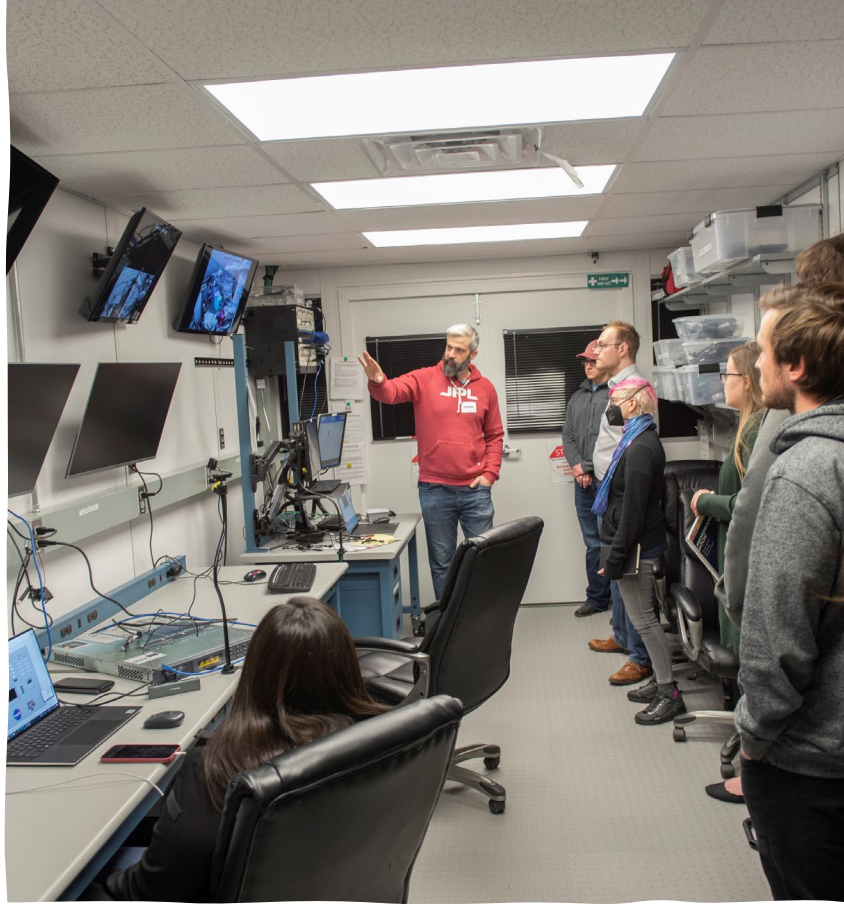
NASA continues to address aging workforce concerns in the field by providing new learning opportunities, mentorship, and hands-on training for entry-level parts and radiation engineers and university students, within NASA and via work with external cohorts

Parts Engineering	NASA EEE Parts 101 Workshop*, at MSFC in 2023, JPL in 2024, virtual attendance open to NASA partners	NEPP ETW training tutorials*	MIL-SPEC training and new specification initiatives at various conferences and workshops*	NEPP Parts Engineering School*
Radiation Effects & Analysis	Rad101 short courses at various conferences and workshops*	Radiation Testing Hands-On Training* ➢ TAMU Bootcamp ➢ MDA Radiation Test Workshop at NSRL	Single Event Effects University Seminars*, hosted by Stony Brook Univ./BNL, available online at https://nanohub.org/	UMD Satellite Design graduate course* (ENAE 691)	NASA employee course "Introduction to Radiation Assurance for SMA"

*** Collaboration with external agencies and/or academia**







All Photos Courtesy of Chris Jarvis

Workforce Development

3rd round of the Texas A&M University (TAMU) Bootcamp Mar 5-8

- Hands-on training in single-event effect (SEE) radiation testing of electronic components with heavy ions
- Model for additional radiation test workshops led by DoD at NSRL and LBNL

NASA / NEPP Parts Engineering School Program

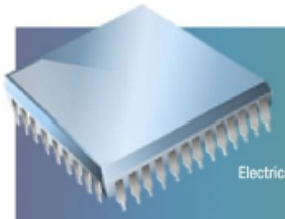
NASA Parts Bulletin distributed at NEPP ETW and posted to NSC SMA website: https://sma.nasa.gov

- Update in progress to reflect new activity since publication

Certificates and Master's Degree program offerings at partnering universities to supply the needed educational basis for the current and future parts engineering workforce

National Aeronautics and Space Administration

NASA



EEE Parts Bulletin

Electrical, Electronic, and Electromechanical

A periodic newsletter of the NASA Electronic Parts Program / NASA EEE Parts Assurance Group and the Jet Propulsion Laboratory

Volume 15, Issue 1, May 26, 2023

NASA Parts Engineering School

The NASA Electronic Parts and Packaging Program (NEPP) is encouraging the development of a NASA Parts Engineering Program alongside university partners Auburn University and University of Maryland, through NASA center-wide collaborations between NASA Jet Propulsion Laboratory (JPL), Goddard Space Flight Center (GSFC), Marshall Space Flight Center (MSFC), and Langley Research Center (LaRC). The program will address the knowledge gap in the current electronic parts engineering workforce and will lead to increases in the number of trained professionals in the workforce, including cultivating the next generation of Parts Engineers.

OPPORTUNITY

With new developments in EEEE parts, there is an ever growing knowledge gap for incoming Parts Engineers

- The need to address this gap has been prevalent through all NASA facilities and involved industries.
- It is critical to tackle the lack of awareness as well as the lack of technical knowledge.
- Currently, there are no programs offering a comprehensive parts engineering focus either at universities or throughout industries in the field.

SOLUTION

Workforce Development at a national level to narrow the knowledge gap.

- Leveraging the knowledge base of the universities and industry partners will assist in filling these gaps.
- NASA to provide guidance in developing university programs to support the aerospace, military, and industrial community

PROGRAM GOAL

Parallel Workforce Development

- Encourage the development of a curriculum of EEEE parts engineering topics at the university level.
- Expand and share training materials currently offered to NASA EEEE Parts Engineers.

NASA Parts Engineering School

- Current Electronic Parts Engineering Certificate and Master's Degree programs with Auburn University, UMD, and UCF
  - NEPP website announcement: https://nepp.nasa.gov/pages/NPES/
  - Program website: https://www.jpl.nasa.gov/go/parts-engineering-school, with links to each university website for enrollment
  - UCF will be the first school or offer an Electronic Parts Engineering Certificate in Summer/Fall 2024 (Master's Degree to follow)
- Kick-off discussions held with Univ. of California, Berkeley and Virginia Tech
- Upcoming presentations to MDA Parts, Materials, and Processes Board (PMPB) Annual Meeting on Apr 2
- Development of additional parts engineering coursework into the 2nd spin of the NASA EEE Parts 101 Workshop at JPL Dec 5-6
  - Half-day Parts 101 workshops to be given at the Aerospace Space Parts Working Group (SPWG) and Components for Military & Space Electronics (CMSE) Conferences in Apr/May

NASA Electronic Parts and Packaging Program

NEPP NASA Electronic Parts and Packaging Program

Home | Parts | Packaging | Radiation | Publications | NASA Parts Engineering School | Training | Tin Whiskers | NPSL | NEPP ETW

NASA Parts Engineering School

The NASA Electronic Parts and Packaging (NEPP) Program is encouraging the development of a NASA Parts Engineering School Program via collaboration with NASA Centers and university partners. ***Learn more...***

Event Announcement: NASA EEE Parts Engineer 101 Training Event hosted by JPL - Online Only

December 5 - 6, 2023

Registration is open to everyone

prev next

About the NEPP Program

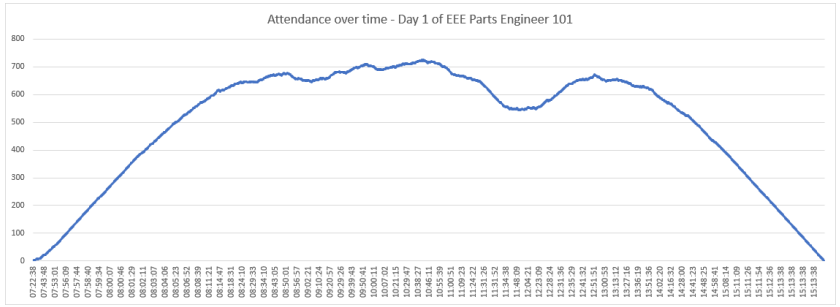
The NEPP Program generates technical knowledge and recommendations about electrical, electronic, electromechanical (EEE) part performance, application, failure modes, test methods, reliability and supply chain quality within the context of NASA space flight missions and hardware. This information is made available to the NASA and high-reliability aerospace community through publications, web pages and links published on this website.

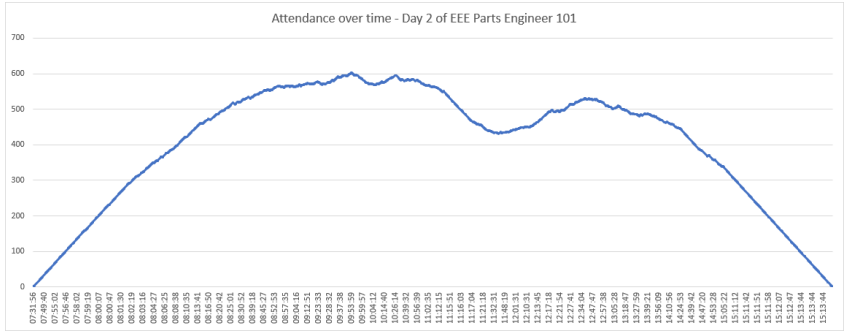
View the NEPP Charter



EEE Parts 101 Workshop at JPL Dec 5-6

Peak attendance:
Day 1 – 725, Day 2 – 603





Agenda (all times PDT USA)

Tuesday, December 5th

8:00 am - 8:15 am	**Training Overview** Shri Agarwal, JPL **Welcome Statement** **Opening Remarks** Dr. Laurie Leshin, JPL Director
8:15 am - 10:30 am	**Parts Engineering School Discussion** NASA School Team Auburn University University of Maryland University of Central Florida
10:40 am - 11:30 am	**Radiation Training** Steve McClure, JPL
11:30 am - 12:30 pm	**Lunch**
12:30 pm - 3:00 pm	**EEE Parts Tutorial**

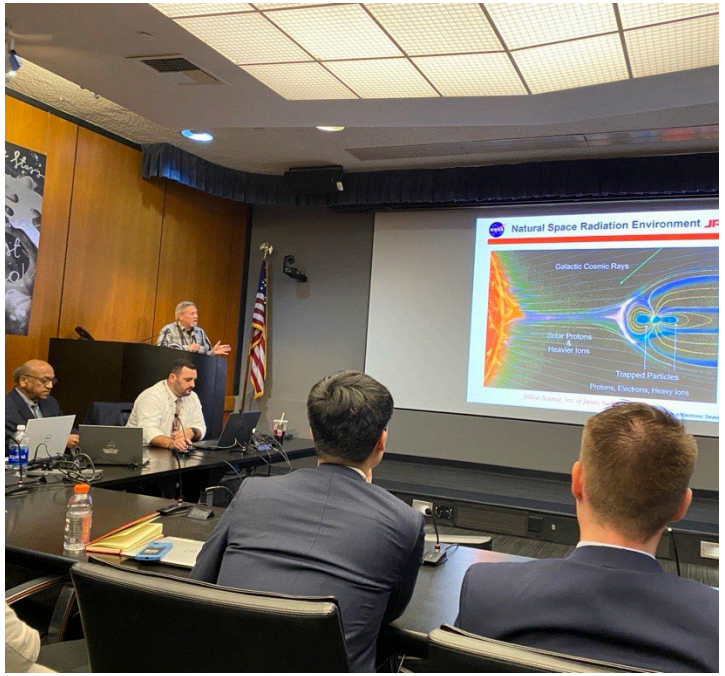
JEDEC, SAE	Shri Agarwal, JPL
Alternate Grade Parts	Mark Porter, JPL
Failure Analysis	Sultan Lilani, Integra Technologies
Silicon Carbide and Gallium Nitride	Rod Deleon, Boeing

Wednesday, December 6th

8:00 am - 8:45 am	**Parts History into Current State** Lyudmyla Ochs, GSFC
8:45 am - 9:30 am	**Basics of Failure Analysis** Lyudmyla Ochs, GSFC
9:30 am - 10:00 am	**Parts Number Decipher** Carlton Faller, JSC
10:00 am - 11:30 am	**Mil-Specs** Larry Harzstark, Aerospace Corp
11:30 am - 12:15 pm	**Lunch**
12:15 pm - 1:00 pm	**Failure Mechanisms** John Evans, NASA Headquarters Bhanu Sood, NASA Headquarters
1:00 pm - 3:00 pm	**Fracture Mechanics**

Intro to Fracture Mechanics	John Evans, NASA Headquarters Bhanu Sood, NASA Headquarters
Fracture Mechanics Status	Shri Agarwal, JPL Nazia Ovee, JPL
FM Testing of Small Packages	Scott Popelar, Frontgrade Ben Mendoza, Golden Altos Nazia Ovee, JPL
Findings from NESC Testing of Copper Wire Bonds	Linda Del Castillo, JPL
FM Testing of Large Packages	Reza Ghaffarian, JPL Ray Kuang, Microchip
In-House Test Capabilities	Sergeh Vartanian, JPL Nazia Ovee, JPL Gustavo Jimenez, JPL

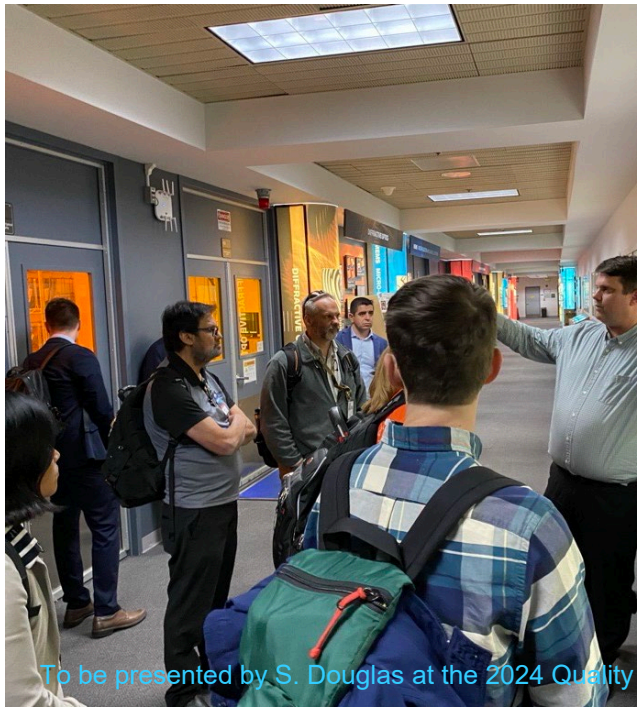
EEE Parts 101 Workshop at JPL Dec 5-6



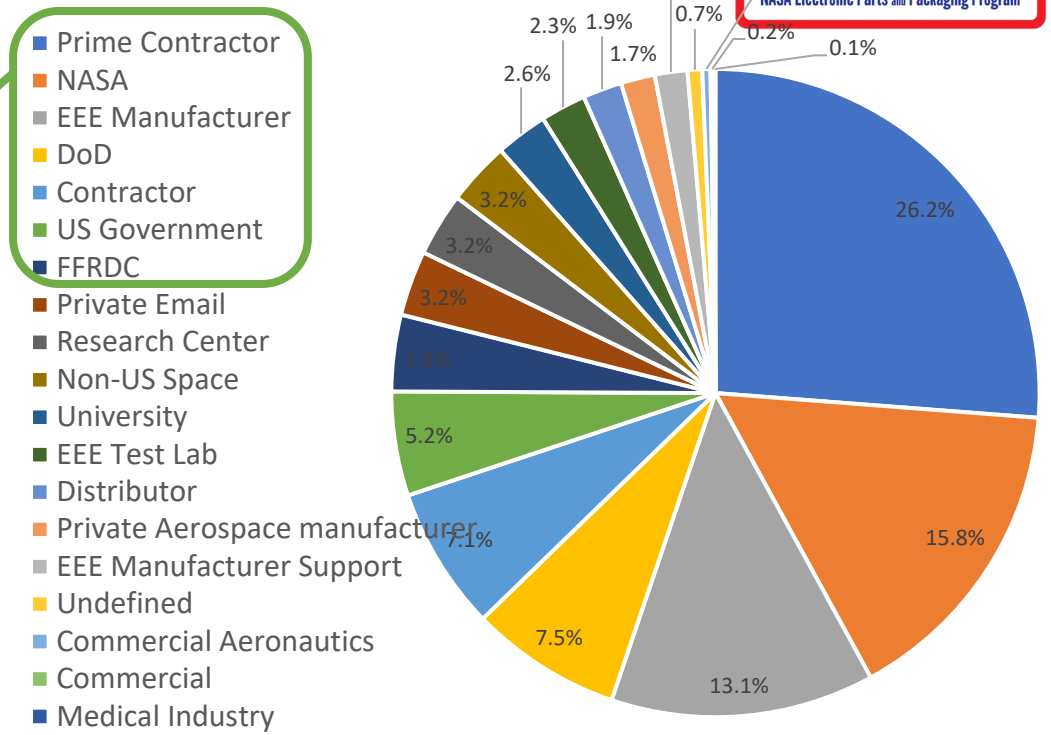


1/4 of attendees from the large prime contractors (Boeing, Northrup Grumman, etc.)

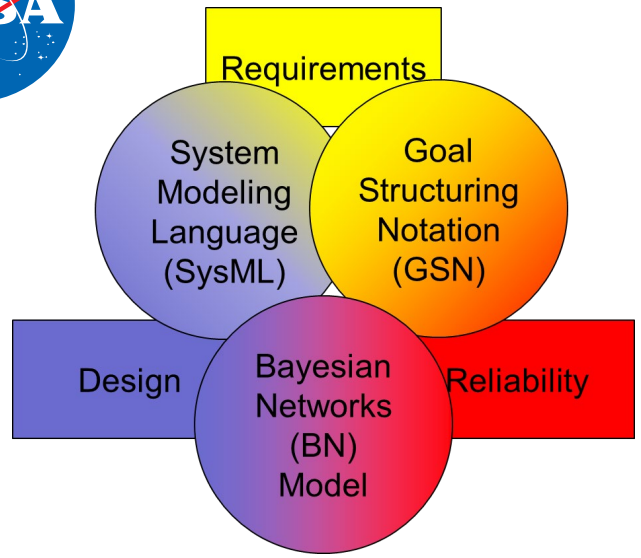
2/3 of attendees from U.S. Government Agencies / FFRDCs



Registration Demographics



- 986 unique registrations on Webex
- In-person attendance by:
  - 16 non-JPL NASA personnel
  - UCF, AU, and UMD professors, who presented on the Parts Engineering School Program details
- JPL Afternoon tours provided onsite



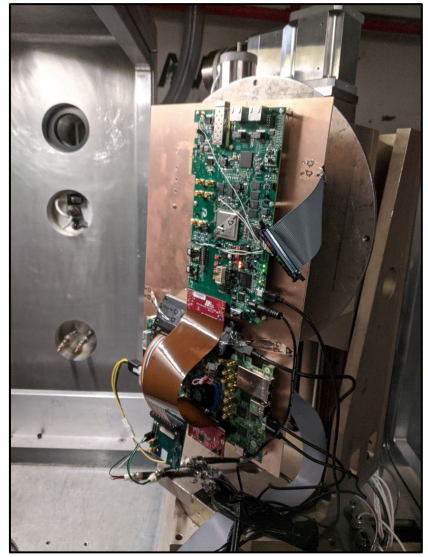
Emerging Assurance Methods
Image Credit: Vanderbilt University

14th Annual NEPP Electronics Technology Workshop (ETW)

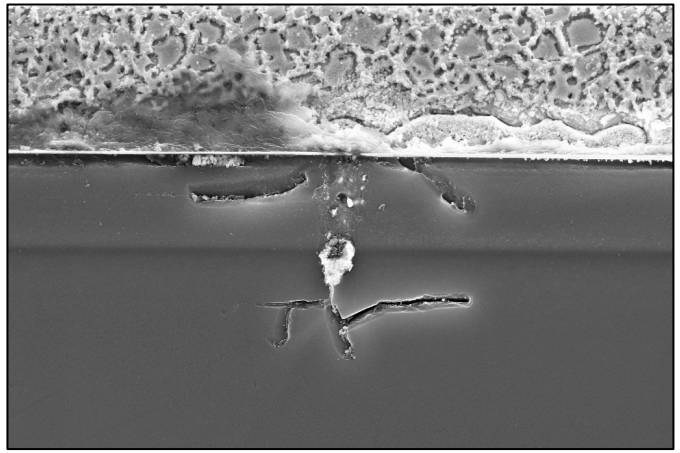
Scheduled dates:

June 3-6, 2024

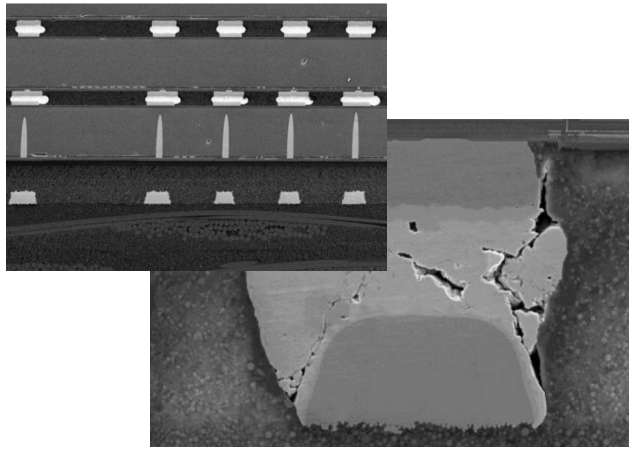
https://nepp.nasa.gov/



Radiation Testing & Analysis
Image Credit: NASA



Advanced Technology Reliability
Image Credit: NASA



Advanced Microelectronics Packaging
Image Credit: NASA

2023 NEPP Electronic Technology Workshop (ETW)

MILSPECs / Standards & Policies

Collaborations / Working Groups

Photonics

Processors, FPGAs, Memories

Wide Band Gap

Advanced Packaging (2.5/3D)

Passives (Capacitors, Resistors, Wire/Connectors)

COTS Utilization / Small Sats / Model Based Mission Assurance (MBMA)

Training / Tutorials

- Polymer Tantalum Capacitor Guidelines
- Statistical Interpretation of Life Test: MIL/JEDEC Requirements Comparison
- PPAP Tutorial

All NEPP ETW presentations for 2023 and past years are at https://nepp.nasa.gov/

The End